aminer has displaced, with great advantage to all concerned, the aforetime local coroner. And if, as there is much reason to suspect, local influences and prejudices make it almost everywhere difficult to secure able and aggressive local boards of health, then the experiment should be tried of having district, county or state officials, authorized and willing to do the necessary sanitary work. The present plan is a failure experimentally demonstrated; let us continue to invoke the experimental method, in which we believe, but abandoning our present customs, which have been experimentally proved—for the thousandth time—to be hopeless, and trying something more promising. We can not do much worse; we ought to do much better.

WILLIAM T. SEDGWICK.
MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

SYMPOSIUM ON YELLOW FEVER AND OTHER INSECT-BORNE DISEASES.

The Protozoon Life-Cycle: GARY N. CALKINS.

The wonderfully successful results obtained in New Orleans in the struggle against *Stegomyia fasciata* has shown that in yellow fever, as was long the case in smallpox, protective measures may be understood and applied, although the specific cause of the disease is unknown.

I do not intend to discuss the question as to whether this specific cause is a bacillus or a protozoon, nor to consider the various organisms that have been found in infected yellow-fever mosquitoes. I purpose, rather, to speak upon some of the general biological phenomena distinctive of protozoa, and of the variations in vitality at different periods of the life-cycle, and then to point out in how far the present data regarding the yellow-fever organism agree with these established facts.

The protozoa are minute animals, consisting for the most part of single cells having an independent life. They vary in size from minute forms, too small to be seen with the highest powers of our modern microscopes, to giant forms from two to three inches in diameter. The vast majority thrive in seas and lakes, stagnant pools and ditches, and are absolutely harmless to man; indeed, they become a boon to him by giving to thousands of microscopists the materials for a fascinating pastime. A small minority are parasitic, but these few cause vast epidemics among silkworms, fish, and domestic animals, and have been the means of great economic loss, or, through malignant human epidemics, have terrorized whole communities and have brought about untold loss of life.

A protozoon rarely retains its individuality more than a few hours. It then divides into two, or, in some cases, into a larger number of daughter individuals. The parent organism has not died, there is no unicellular corpse, but the protoplasm of which that organism was composed is now distributed by division among two or more individuals. The process is repeated again and again, and thus it continues, a repetition of growth and reproduction. We can not speak, therefore, of the life-cycle of an individual protozoon, but must consider rather the protoplasm of which that individual is composed. It is this protoplasm that goes on through generation after generation of individuals, and through all the phases that constitute the aggregate of phenomena which has been termed the life-cycle.

It was formerly believed that this protoplasm, having all of the necessary functions required for an indefinitely continued existence, gives to the protozoon the attribute of an endless life—physical immortality. Experiments made within comparatively recent times have shown, however, that this is not true and that the protoplasm of a given protozoon gradually loses its

vitality with continued division or asexual reproduction, until it ultimately dies of old age no less surely than does the protoplasm that makes up the tissues and organs of higher animals. It is known that a protozoon immediately after conjugation with another of its own kind, a process which agrees in essentials with the fertilization of an egg by a spermatozoon, has a high potential of vitality which enables it to live and multiply asexually for a long period, with, however, a gradually decreasing vitality which, unless renewed by conjugation, ultimately gives out, the protoplasm dying of old age. Conjugation, then, appears to be a process of rejuvenescence and has been so interpreted since the classical experiments of Maupas in 1888 and 1889.

In every protozoon life-cycle, in free living and parasitic forms, we can make out, with more or less precision, three phases which correspond with analogous phases in the life of a metazoon. The vigorous, actively dividing forms are found in the period immediately after conjugation and this period corresponds with the period of youth. The conjugating period, or the time when the protoplasm is capable of renewing its vitality by conjugation, corresponds with the period of adolescence, or maturity, and, in the forms which have not conjugated, the period of increasing degeneration and old age compares with the old age of metazoa.

The study of many types of protozoa has shown that with decreasing vitality there are frequently marked changes in the form of the body and in the physical composition of the protoplasm. These changes are most marked at the period of sexual maturity, when they frequently give rise to structural modifications as widely different as the egg and the spermatozoon. It is while in this condition of the protoplasm that sexual union take place and, through this, renewal of vitality and return to the type form. This condition of the protoplasm, which indicates a modification of the physical organization of the protozoa at periods of adolescence, comes sooner or later in the history of any life-cycle, but it can also be induced artificially in many cases. Thus it has been possible to change ordinary asexual flagellated protozoa into sexual forms by increasing the density of the surrounding medium through addition of sugar, etc.; or by lowering the temperature, perhaps again, a matter of density. In a number of parasitic forms, some of which affect the welfare of human beings, a similar change in environment is a normal part of the life-cycle, and is brought about by insects, sometimes mosquitoes, sometimes ticks and sometimes flies. The asexual protozoon organisms are transferred from the warm blood of birds or mammals, or man, to the cold environment of the insects' digestive tract. This is accomplished in the case of malaria by mosquitoes belonging to the genus *Anopheles;* in the case of bird malaria by mosquitoes belonging to the genus *Culex;* in the case of sleeping sickness by the tsetse-fly; in the case of Texas fever among cattle by ticks belonging to the genus *Boophilus.* Where the full life history has been made out, it has been found that conjugation takes place within the body of the insect and here, therefore, vitality of the parasite is restored.

What is known to take place in some of these well-authenticated cases is presumably true in the case of yellow fever. The blood with the organisms in it is taken into the digestive tract of the mosquito (*Stegomyia fasciata*), and here, or in some other organ, the germ probably passes through some developmental cycle, for a period of twelve days is necessary before such infected mosquitoes can transmit the disease to another human being. The similarity to the malaria organisms in the

period of incubation, as well as in the change of hosts, is a striking argument in favor of the protozoon nature of the yellow-fever germ.

The different forms which protozoa assume at various periods of the life-cycle have been frequently mistaken for different species or different genera, and well-known cases such as *Plasmodium* and *Polymitus*, or *Coccidium* and *Eimeria*, where the different phases were regarded for a long time as distinct types of organisms, justify the view that the entire life-cycle should be taken into consideration when describing species. The changes in form at the different periods are due, as I believe, to the differences in vitality.

[Here a number of lantern slides were shown illustrating the variations in structure, etc., in various types of protozoa.]

In *Tetramitus* the free-living asexual forms have a definite membrane and a definite body form and continue to multiply by simple division for a period of two or three days, when the definite membrane becomes plastic and the body assumes more or less amœboid forms resembling the genus Mastigamœba. In this condition of the protoplasm two individuals upon coming together fuse into a common mass, their nuclei unite and conjugation is effected. After conjugation a firm cyst is secreted within which the protoplasm divides into hundreds of parts, which escape from the cyst, finally, as young flagellates.

In *Polystomella* the polymorphism is shown by two types of shell and by different forms of the young organisms. In the microsphæric type there is a characteristic fragmentation of the nuclei into many chromatin particles of small size. This is followed by formation of amœboid spores, which develop into shelled forms of a different type from the first (macrosphæric), and these in turn give rise to flagellated spores which conjugate.

The decrease in vitality can be measured in a rough way and the relative vitality at different periods can be easily compared. This has been done in the case of some of the free living infusoria, for example in *Paramœcium, Oxytricha,* etc. For such comparisons a single individual is isolated and within twenty-four hours it divides. The daughter cells are similarly isolated, and this process is repeated until the protoplasm under observation dies from exhaustion of vitality, in one case (*Paramœcium*) after twenty-three months of observation, during which time 742 divisions were recorded. When averaged for ten-day periods these divisions gave a satisfactory measure of the vitality at different times during the cycle. It was found in these experiments on *Paramœcium* that after about 200 generations the vitality is apparently exhausted, but that it can be restored by artificial means and stimulated to a new cycle of about 200 generations. Ultimately, however, artificial stimuli failed to renew the vitality and the race died out in the 742d generation. Such artificial stimulation suggests the possibility that in certain human diseases, such as malaria, the organisms may become exhausted so far as the division energy is concerned, but may remain quiescent in the system, hibernating, as it were, in some organ until, owing to some change in the chemical composition of the blood, an artificial stimulus renews the division energy and a recurrence follows.

Turning now to the data that have accumulated in regard to the organism of yellow fever, we must note that the rapid development in the blood indicates a high potential of vitality; that the disappearance from the blood indicates that the organisms have been killed off through excess of their own toxins, or by accumulation and action of the anti-bodies. The long period of incubation in the mosquito

indicates that processes are taking place in the development of the germ which can be explained only on the supposition that conjugation phenomena, analogous to those in the malaria mosquito, are taking place, and this supports the view that in the human blood the organisms are endowed with a high potential of vitality. Again, the filtration experiments in which it has been demonstrated that the organisms may pass through the finest filters known to us, indicate that the organism is among the smallest of living things, and belongs to that group which is rapidly becoming more than hypothetical, the ultra-microscopic forms. The small size may be a result of rapid multiplication, and it is not improbable that after the incubation period larger forms will be recognized in the digestive tract of the mosquito and in the salivary glands.

Finally, if the organism is a protozoon there is only a limited possibility as to its systematic position. Larger forms like *Trypanosoma* would not pass the finest filters; corpuscular parasites like *Piroplasma* would likewise be filtered out, besides which the yellow-fever organism is known to be a plasma parasite. A single genus of protozoa is known at the present time that fulfills all of the conditions of the yellow-fever organism; amongst its species are some that are at times ultra-microscopic; that have a characteristic change of hosts from warm-blooded forms to mosquitoes and that are characterized by remarkable virulence. This is the genus *Spirochæta* and in it alone, at the present time, do we find the type that satisfies all of the conditions known of the organism of yellow fever.

Dr. James Carroll said in discussing Professor Calkins's paper: "I have listened with the greatest interest to Professor Calkins's exposition of the life histories of protozoa and I am reminded by it of a series of hypothetical experiments that for some time I have felt a great desire to see performed and which might throw a flood of light on the nature of the parasite of yellow fever. Reasoning from the standpoint that the organism is an obligate animal parasite, a series of passages through the human being by means of direct inoculations with blood, without the intervention of the mosquito, should gradually bring about attenuation or eventually render it incapable of further reproduction in man, by restricting its existence to a single phase of its life-cycle. Such a result would almost conclusively indicate the kingdom to which it belongs, but the deterring factor is, of course, the risk to human life."

Filariasis and Trypanosome Diseases: Henry B. Ward.

The presence of microscopic nematodes in the blood was recognized as early as 1872, though their separation into distinct species has not even yet been fully accomplished. The best known of these embryonic forms is that belonging to *Filaria bancrofti;* it was shown by Manson to manifest definite periodicity in its occurrence in the peripheral circulation, and hence was designated *Filaria nocturna.* During the day this form retires to the capillaries of the lungs. For further development it must be taken up into the stomach of a mosquito, from which it wanders out actively into the thoracic muscles and there assumes a quiescent stage. There appears to be no definite generic adaptation as in the case of the malarial and yellow fever organisms, but various species of *Culex* and *Anopheles* may serve as intermediate hosts. After a period of rest and growth covering fourteen to twenty days the larvæ become migrants and move through the lacunæ of the body into the proboscis. The precise method of transference into a new host is not yet clearly demonstrated, but the filariæ

are next found as adults coiled in lymph glands. The enormous mass of embryos produced by the females blockade locally the lymph vessels and the resulting lymph stasis leads mechanically to dilatation of the tissues and increase in the size of parts which shows itself as varicose glands, chyluria, or elephantiasis. After brief reference to other species which are only insufficiently known, reference was made to the occurrence of these forms in the western hemisphere and to their presence also in various parts of the United States. The author emphasized the need of careful studies on the anatomy of both adult and larva to enable the diagnosis of various species, and on the life history and transmitting agents to explain the spread of the parasite and the means of prevention. Attention was also called to the relations of these forms to various domestic and wild animals as facultative hosts and possible means therein of the multiplication and spread of species, while the advisability of search for the embryo forms in the blood and the need of more detailed and accurate knowledge of the pathological changes induced in the human body were noted.

After brief discussion of the morphology of the Trypanosomes their occurrence in a pathogenic rôle was discussed for the nagana, or tsetse-fly, disease of Africa, the surra of India, China and the east, the dourine of horses in the Circum-Mediterranean region, and the mal de caderas among horses on the Pampas of South America. Dutton in 1901 discovered a related species in the blood of a European who had been resident on the Gambia River in Africa, and the relative frequency of such cases together with their distribution over the territory bordering on the Gambia and Congo was noted. The same form was discovered by Castellani in 1903 in the cerebro-spinal fluid of negroes suffering from 'sleeping sickness' and gave the key to the etiology of that disease. The life history of these forms has not yet been elucidated unless the recent work of the Koch expedition to Africa has succeeded in solving it. It is reasonably clear, however, that these organisms pass through one phase in the life-cycle in the body of some transmitting agent, which is probably a blood-sucking insect. The discovery by MacNeal and Novy of a method by which such forms may be cultivated in the laboratory marks a great advance and has been successfully used to detect the presence of forms not demonstrable in preparations of the blood itself. It has not availed as yet to furnish any method of treatment for the diseases produced by the organism. The phase represented in such cultures is undoubtedly only the asexual. A brief discussion followed of related forms, such as the *Spirochæta* of the owl studied by Schaudinn, of the species present in syphilitic lesions and of the Leishman-Donovan bodies; and the importance which these observations have, though incomplete, was pointed out in indicating the life history and pathological significance of the group. The author also indicated the necessity of study to determine the intermediate hosts which subserve various parasites, to secure more perfect knowledge of normal blood, and emphasized the value of more general and precise examinations of the excreta and body fluids which would be likely to disclose the presence of other organisms of this type as yet unsuspected.

The Practical Results of Reed's Findings on Yellow Fever Transmission: J. H. WHITE.

1. For the first time since Reed, Lazear and Carroll did their great work in Cuba, the opportunity offered, in 1905, in the city of New Orleans, to demonstrate on a scale of such magnitude as must needs be impressive, the true value of that work.

2. I have no desire to underrate the work done in Havana. It was a noble accomplishment, and one that should immortalize its doers, but we must remember that the Cuban city had a population ninety-five per cent. of whom were immune, and was built upon high and dry ground, while the population of New Orleans was at least seventy-five per cent. non-immune, the city itself being a perfectly natural habitat for the mosquito.

The fight began in Havana in the early spring, against two or three cases. It began in New Orleans under the blazing sun of late July, and against hundreds of cases.

3. There were two distinct organizations in the city of New Orleans, each one having the same object in view and working in cooperation with each other. The Citizens Volunteer Ward Organizations sought to destroy all mosquitoes by the screening and oiling of cisterns, by the oiling of gutters and pools, and a desultory sulphurization of houses. This last they could only accomplish by pleading with the people to do it, and nothing like perfection in this line was ever attained at any time, the *laissez faire* of the attitude of the people in general upon this question being too well known to need comment.

4. The regular organization consisted of a central headquarters, with, at first, sixteen, and subsequently eighteen, ward headquarters, corresponding, practically, with the political geography of the city. Each of these subheadquarters was in command of a medical officer, provided with from one to six medical assistants, according to the needs of his station, and kept in touch with the central office through the medium of an officer who served as adjutant. Each subdivision had its own gangs of inspectors, screeners and fumigators, and was furnished with all necesary supplies from a purveying depot established for that purpose.

5. Upon the report of a case of fever, either suspicious or yellow, to the city board of health, the central headquarters or the ward headquarters, the information was immediately conveyed to the commanding officer of the ward concerned, and a screening gang at once started for the house, placing screens and, if need be, mosquito bars around the patient, who, if his condition permitted it, was moved into another room, his own room fumigated and he then returned thereto, the rest of the house being at once fumigated. All cracks were pasted over from the inside and all chimneys attended to at the earliest possible moment in order to prevent their becoming the hiding-place of the infected *Stegomyia*. Before the expiration of twelve days, a second fumigation was resorted to in order to be sure that no infected mosquitoes escaped.

6. Our work with its results fully justifies the assertion made by Dr. Carroll, that the best policy is to treat all cases of fever as worthy of suspicion. There is no doubt that during this fight there were thousands of unnecessary disinfections done, but it was just as necessary as any other part of the work, as long as no man can always be relied upon to make an exact diagnosis in any disease, the causative entity of which is not definitely known, hence we did not wait for definite diagnosis, but disinfected first and secured the diagnosis when we could.

7. Of course any sick persons willing to go there were removed to the emergency hospital provided for the purpose, and so carefully screened and safeguarded against mosquitoes in every way as to render the use of mosquito bars unnecessary.

In the original infected area house-to-house inspection, and, indeed, house-to-house disinfection, were kept up continuously from the latter part of July until about the first of October. All over the

city house-to-house inspections were made to some extent, and this work was largely instrumental in forcing the report of cases which, otherwise, might never have been reported and might have served as seed for a future distribution of the disease.

8. With a view to the general elimination of the mosquito, we salted 750 miles of street gutters, using some 3,000,000 pounds of rock salt to form a minimum solution of five per cent., and in so doing incidentally cut the malaria rate down to almost *nil.*

9. One of the most serious problems of yellow fever has ever been, and was this year, that of transportation. In order to satisfy public clamor, we disinfected cars, both passenger and freight. We relayed passenger coaches and cut out Pullman traffic, so far as direct entry into the city was concerned.

10. I am strongly of the opinion that most of this car disinfection and relaying was unnecessary, and in support of that view I wish to call attention to the fact that, having an abiding faith in the ideas which I shall hereafter state, I purposely omitted any relay or disinfection of the Louisville & Nashville coaches out of New Orleans, going to the Alabama state line, where they were relayed. These coaches went from the city of New Orleans, traversing the entire width of eastern Louisiana and southern Mississippi, a distance of 116 miles, every day and every night, without any precautions whatever being taken until some weeks after the beginning of the outbreak, and then the windows were screened.

These cars were boarded by Mississippi National Guardsmen who served as quarantine guards, and who traveled *in the cars* with the passengers, from the western to the eastern border of the state of Mississippi and back again, day and night, in dry and in humid weather, for the whole period during which yellow fever existed in New Orleans. There were some score of them so exposed to any infection which might have existed in these coaches, but not a single one of those men so acting as train inspectors, nor any of the train crews, was taken sick with any kind of fever whatsoever, and I wish, in concluding this particular portion of my remarks, to accentuate the fact that these coaches traveled up and down Elysian Fields street in the city of New Orleans, on both sides of which street the infection was rampant, as well as up and down the river front of the city, passing the original infected area where the infection was most prevalent, thus determining, at least to my mind, as strongly as circumstantial evidence may determine anything, that the infected stegomyia does not travel to any noticeable degree; that *she remains,* as nearly as she may, at the place *where she first tastes blood,* and will not voluntarily leave a house, much less cross a street.

11. The case in which she can not find food, water and seclusion in the habitat she chooses at her birth is rare indeed, and finding these, she needs no more.

She can not abide the glare of a midday sun, as shown by Berry, of the Public Health and Marine Hospital Service, who found this species killed by two minutes' exposure to a noon sun, in Texas, in 1903.

We must not attempt to reason from analogy with other species, and be led into error because others do travel. The *Stegomyia* is a domesticated species and may be justly likened to the quiet German peasant, while the *Culex solicitans,* like a wandering Bedouin, rises from her native marsh and willingly drifts with the wind. Unlike the *Stegomyia,* she has no home and wants none. She is not choice as to her meal of blood—any old hide will answer the purpose.

The rarity with which the stegomyia

migrates has been indicated many times by the frequency with which houses so close to the infected dwelling as to be almost contiguous, have escaped infection. It is further illustrated along the same lines as those I have already mentioned in regard to railroad cars, by the fact that in each case in which we have been able to trace the manner of infection in a city or town, it has been found that the locality was infected by some person who, arriving there during the incubative period of the disease, subsequently developed the fever. In no instance has there been any legitimate evidence which would point to any other method of infection.

I believe the idea prevailing among some people with regard to the traveling of the infected mosquito, to be a bugaboo, though I do not desire to be understood as saying that the stegomyia never does travel. It unquestionably does, but only because in the incipiency of its life it has taken up its habitat in a car instead of a house, or because accidentally imprisoned in a box or a drawer, it is carried, *nolens volens*, but rare, indeed, are such cases.

I have been quoted by Dr. Rosenau, in his work on disinfection and disinfectants, as saying that 'disease more often crosses the street in a pair of shoes than in any other way.' It was to yellow fever that I alluded in our conversation about this in 1898.

12. So confident were we of the absolute truth of the mosquito law, that right from the beginning we brought yellow fever patients from points outside of the city, and placed them in the hospital here, believing that in so doing we ran no risk of increasing the infection. We allowed people from infected points in the state, such as Patterson and Tallulah, and from the infected localities of Mississippi, to come into this city with no other precaution than that they should be provided with a certificate that they were not from an actually infected house and were in good health when they started. We had no trouble whatever on this score, and to the credit of American manhood and womanhood be it said, the addresses given by these people as their intended residences in the city were absolutely and invariably correct, and all of them were inspected, without difficulty, during the first six days of their sojourn here. The only trouble we had from incoming persons was occasioned by those who sneaked in from contiguous localities, and consequently evaded the daily inspection, as they had already ignored the requirement that none who came from an actually infected house should be admitted.

13. Yellow fever is so easy of control, if only the medical profession and the people will be frank and honest with the health officers, that it seems a crime against humanity that we must needs quarantine such a disease. There is no more rationalism in quarantining yellow fever than there would be in quarantining typhoid. Indeed, there is less, because it may be stated as an absolute and invariable law, that a case of yellow fever known in the first two or three days of its existence, and to which proper measures can be applied, presents absolutely no menace to the community, nor even to the family resident in the house with it. Until, however, such laws are enacted and enforced as will make the concealment of a case of yellow fever, either through the complaisance of the family physician or the cowardice of the family, a crime and an absolute impossibility, there will continue to be more or less of quarantine—probably more. Such laws are deemed by many people an interference with individual liberty and incompatible with the rights of American citizenship, and similar buncombe, *ad libitum*. The only other alternative, and a most excellent

one, too, will be the passage and enforcement of laws insuring the proper sanitation of our cities, this being a matter which offers so many other advantages in addition to the removal of yellow fever, as to make it appear to my mind the most imperative need that confronts the south as a whole, and the really proper solution of the entire matter.

14. It would be a false claim, if set up by any of our great northern cities, that they intelligently got rid of yellow fever, for it is a fact which must be apparent to all of us, that they did nothing of the kind. They intelligently provided themselves with municipal utilities which appealed strongly to their ideas of creature comfort and general cleanliness, and which, incidentally and entirely accidentally, eliminated the mosquito at the same time. These public utilities were a thoroughly controlled water supply, sewerage, drainage and pavements, and these four, not one, but all of them, were essential to the end attained.

We may rid the city of New Orleans of yellow fever, but we shall never rid it of its susceptibility to that disease until these four requirements are complied with, and the possession of these public utilities will also do away with many of the other 'ills that flesh is heir to.'

It is irrational to go on, year after year, fighting only the infected mosquito, when we can, with a little more trouble, destroy all mosquitoes once and for all. To put the matter plainly to the business man who is, after all, the court of last resort, make an investment now in good health, and it will pay you enormous dividends in increased business, in reduced loss of time by yourself and your employees, and in that priceless boon that comes only to the man free from any taint of disease—the one only thing that makes our north superior to our south—the pure joy of living.

I would briefly summarize the matter thus:

1. The only true way to fight yellow fever is to wipe out all mosquitoes by water supply, sewerage, drainage and paving.

2. As a palliative measure or temporary expedient pending the first proposition:

(*a*) Compel the report of all fevers.

(*b*) Screen all fever patients.

(*c*) Use a culicidal agent in all dwellings of the sick, at once, and again before twelve days have elapsed since patient sickened.

(*d*) Authorize inspection by health officer of any patient.

Though perhaps out of place, let me pay a well-deserved tribute to the patriotism of the citizens as a whole, and to the citizens' committee, the clergy and the medical profession, and finally, to that gallant band of officers, some sixty in all, who worked in the dust and sweat of August with untiring zeal, and particularly the score who were my captains and did such duty as, had it been rendered to the first Napoleon, would have been rewarded by a marshal's baton.

Difficulties of Recognition and Prevention of Yellow Fever: QUITMAN KOHNKE.

The doctrine of the mosquito conveyance of yellow fever, for the practical application of preventive measures based thereon, may be expressed thus:

The immediate causative factor, the germ of the disease, is accessible to the only natural vehicle of infection, the mosquito, during the first three days of the fever, and the germ after entering the mosquito's stomach requires twelve days to reach one of the salivary glands, from which the insect, while feeding, may inject it into the blood stream of its victim, in whose system the period of incubation is usually from three to five days, rarely six.

The human subject of the disease may be considered infectious, therefore, to the mos-

quito during the first three days of the fever, and not thereafter; the mosquito being infectious after the twelfth day from the date of inoculation, and not before. Its victim shows the first symptom of disease usually in less than five days after infection by the insect.

The exceptions to this rule are not sufficient to suggest its modification, but in actual practise the patient is considered possibly infectious during four days, and the mosquito possibly dangerous on the tenth day.

A case of yellow fever can not occasion another case in less time than the period of incubation in the mosquito, which is twelve days, added to the period of incubation in its human victim, which is not less than three; fifteen days completing the minimum cycle of infection. We may say approximately that explosions of infection should be expected, and are observable semi-monthly, and the result of disinfection can not be determined earlier than fifteen days thereafter. We can not say how many cases may result in about two weeks from one case untreated sanitarily, but we can say positively that no case will result if there are no mosquitoes present of the *Stegomyia* variety. Conversely we may apprehend a great infection in the presence of great numbers of mosquitoes.

The application of the mosquito doctrine to the prevention of yellow fever is all that need be done in any emergency, but to accomplish this is a problem not to be solved by any set formula. It is an easy matter to set down on paper and in an office a lot of rules in the abstract to be carried out in the field, but it is a different matter to apply these rules concretely to actual cases to obtain results.

Circumstances and conditions met with in actual practise may radically change the relative value of details, esteemed of paramount importance theoretically.

As applicable to a locality or community, I wish to place before you three propositions, upon the first two of which is based the third, which is offered in the nature of a conclusion.

1. Quarantine against yellow fever can not be made absolute in its protective value.

2. Early recognition of the presence of yellow-fever infection is difficult always, and at times impossible.

3. The most dependable measure of prevention of yellow fever is destruction of the *Stegomyia fasciata* before the possibility of infection.

Extensive argument is not necessary in an assembly of this kind whose every member is qualified to do his own thinking and form his own conclusions upon the evidence presented.

Quarantine.—In quarantine against yellow fever two essentials are to be considered, and nothing else. Detention of persons exposed to infection for not less than the period of incubation of the disease, and the prevention of entrance of infected mosquitoes.

The increasing rapidity and facility of travel makes quarantine more difficult and less reliable. However near to perfection may be our own maritime quarantine system, we shall always be exposed to infection by rapid land transportation from ports not themselves infectible, or which are less careful for other reasons. Quarantine, though important and necessary, can not ever be all-sufficient.

Early Recognition.—Early recognition of yellow fever, so essential to the prompt application of sanitary remedial measures, is rarely to be expected. The history in this respect of 1897–8 and 1899, as well as that of 1905, exemplifies this, not only in New Orleans, but elsewhere, even in Havana, where better preparation is made and better opportunities offer for the prompt discovery of early cases.

We should not relax our constant watchfulness during the season of danger, but we must realize that knowledge of the existence of first cases requires a combination of factors not always obtainable and not within our practical control.

Destruction of Stegomyia.—Finally, we must, I think, conclude that the destruction of the only natural transmitting medium is the surest preventive of yellow fever. This measure also is subject, of course, to imperfect application in practise, and incomplete results. It is not sufficient, alone, to guarantee against infection, but it offers the important element of time during which to encourage its thorough application; and in the event of the failure of quarantine and of the prompt recognition of infection, the spread of the disease is modified by even a partial destruction of the conveying medium, and this gives time for perfecting organization against the infected insects.

The health authorities of this city were convinced of the truth and importance of the mosquito doctrine of yellow-fever conveyance upon its first announcement, and of the importance of mosquito destruction. Twice a law such as is now operative was proposed and rejected, and our belief is now, as it was then, that the destruction of *Stegomyia* mosquitoes prior to the introduction of yellow fever is the ounce of prevention that is better than the pound of cure.

I show three charts of mortality for three separate years, one of which, 1905, is a yellow-fever year.

The causes of death are those under which yellow fever may be concealed, intentionally or not.

A careful analysis of these records does not bear out the notion, expressed by some, that yellow fever should have been recognized earlier than the middle of July through an inspection of the mortality from these causes.

1905.

	Malaria.	Acute Nephritis.	Bright's Disease.	Enteritis Under Two Years.	Deaths Typhoid.	Cases Typhoid.
January.	0	6	60	11	11	32
February.	4	3	51	10	2	7
March.	2	7	42	7	8	16
April.	3	3	35	25	6	26
May.	5	8	48	116	6	19
June.	5	4	44	91	11	24
July.	11	6	32	38	28	114
August.	6	5	43	18	13	31
September.	2	4	27	24	5	26
October.	2	5	34	11	3	12
November.	5	8	44	14	6	16

1904.

	Malaria.	Acute Nephritis.	Bright's Disease.	Enteritis Under Two Years.	Deaths Typhoid.	Cases Typhoid.
January.	4	5	38	9	9	16
February.	3	5	40	3	7	15
March.	5	8	41	16	2	8
April.	4	7	37	80	6	18
May.	6	3	32	70	10	28
June.	5	4	42	50	13	28
July.	4	5	42	40	11	45
August.	6	6	25	22	14	58
September.	13	5	32	19	12	37
October.	9	10	47	17	10	26
November.	6	8	42	16	10	26
December.	3	5	56	12	7	31

1903.

	Malaria.	Acute Nephritis.	Bright's Disease.	Enteritis Under Two Years.	Deaths Typhoid.	Cases Typhoid.
January.	3	4	53	13	5	16
February.	1	7	53	12	4	8
March.	4	2	53	10	6	13
April.	2	5	39	20	6	13
May.	9	5	41	82	8	28
June.	11	5	30	73	18	55
July.	10	3	39	56	16	59
August.	9	3	51	26	21	79
September.	8	3	54	11	14	66
October.	11	7	51	17	8	25
November.	10	6	49	18	2	24
December.	3	5	50	17	11	26

The value of mortality charts is historic, not prophetic, in respect to yellow fever.

Investigation of individual cases, whose circumstances, together with the given cause of death, excite suspicion, is more reliable than an observance of increase in numbers, and is earlier available. This is

our routine summer practise during the danger period, and was done during the past summer with negative results.

The explosion of infection in New Orleans this year was due to an unfortunate combination of unfavorable conditions, to which was applied the spark of introduced infection. How the fever entered the city is not the official concern of the health officer, who has no function or authority in maritime or inland quarantine. When it got here, however, it found ideal factors for its development and spread. The section of the city first infected is the most densely populated, the people are for the most part ignorant of our language and illiterate in their own. Their habits are unsanitary and their customs such as tend to secretiveness and improvidence. They are not, as a rule, vicious, but fearful of police authority, and exceedingly clannish; as is not unnatural for foreigners in a strange country. Medical attention in case of illness is usually delayed until the severity of symptoms demands it, and any but severe ailments are likely to be followed by recovery without medical interference. They are attended when ill mainly by physicians of their own nationality, some of whom are unfamiliar with yellow fever. They are apt to resent the reporting of any case of commun cable disease to the authorities, and are likely to dismiss the attending physician for this reason. Imagine a crowded population of this kind whose water supply consists in large part of river water, kept for settling purposes in numerous open barrels, each one an ideal breeding place for the *Stegomyia* mosquito.

For more than four years the health officer, encouraged and supported by the board of health, had pointed out the danger; had explained, urged, begged and prophesied, but other considerations were deemed of greater importance than the destruction of mosquitoes. When the disaster came, however, the people of New Orleans, awakened from a lethargic sense of security, rose to the situation and demonstrated their willingness and ability to fight the greatest battle that was ever waged against yellow fever; and they conquered. The united forces of the combined authorities of city, state and nation and the whole people of New Orleans succeeded in turning a great calamity into the most glorious victory of modern times. For the first time in New Orleans an epidemic of yellow fever was fought with the weapons suggested by the doctrine of mosquito conveyance of the disease, and for the first time extensive yellow fever was controlled as early as August.

The first victory over yellow fever was in Havana, the greatest in New Orleans.

The pictures exhibited show the character of the neighborhood first infected, its nearness to the landing place of the Havana steamers (I do not claim, however, that our infection came from Havana) and the facility with which infection could have gotten, and probably did get, to the luggers, the landing place for which is in close proximity; these luggers being connecting links with the gulf coast of Louisiana.

Suspicion was directed to this neighborhood of the city about the middle of July, but subsequent knowledge indicated the real beginning of yellow fever infection to have been probably several weeks earlier. At no time in the history of New Orleans did an epidemic of yellow fever begin to decrease as early as did the latest and we hope and believe the last one.

Never before was an epidemic of yellow fever in New Orleans fought in the same way, and the most skeptical of reasonable persons must conclude that the control of what would have been one of the greatest of yellow-fever epidemics was due solely to the prevention and destruction of mosquitoes.

Dr. James Carroll said in discussing Dr. Kohnke's paper: "The chart by which Dr. Kohnke shows that there was a marked increase in the death rates from pernicious malaria and acute nephritis in New Orleans during the months of May and June, 1905, proves conclusively to my mind that fatal cases of yellow fever occurred in the city during those months and that the disease was probably also present during the month of April. They recall forcibly to my mind an incident that occurred at Pinar del Rio, Cuba, in 1900. During a localized outbreak of yellow fever a number of deaths took place and though some post mortem examinations were made the cases were diagnosed 'pernicious malaria with acute nephritis.' The unusual mortality rate attracted attention and upon investigation it was found that the disease prevailing was yellow fever. As the records of innumerable epidemics show that where yellow fever is wrongly diagnosed it is usually regarded as pernicious malarial or bilious remittent fever, and as death from yellow fever is usually accompanied by acute nephritis or parenchymatous degeneration of the kidneys, the explanation suggested is probably the correct one. This opinion is borne out by the record for July and the following months during which the excessive number of deaths from pernicious malaria and acute nephritis no longer appears, seemingly for the reason that yellow fever was declared in the month of July."

The Practical Side of Mosquito Extermination: HENRY CLAY WEEKS. (Presented by A. C. Eustis.)

In essaying to speak on such a theme before a body of scientists, it must not be understood that the purely scientific side is to be subordinated or is imagined to be of less importance than the practical. On the reverse, the methods under which practical work has been most successful are based entirely on the scientific work of the entomologists. It is through their patient labor that others have been encouraged to carry into practise their findings to their legitimate results. The scientific work of the bacteriologists too has given great strength to the demand for practical work.

Without diminishing their share in the movement it may be truly said, however, that entomologists have always known the fact that the mosquito must have water in which to develop from the larval and pupal stages to the adult. But, as is very generally the case, these students have been, in former years at least, engrossed with the study of the life, habits and structure of these pests and did not carry, and indeed were formerly hardly expected to carry, the knowledge gained into the practical realms of extermination. They may be said to have been working at too close a range to see all the results which their knowledge implied. There was needed the more general survey over the entire subject by practical minds of persons, who knew, perhaps, only the basal facts about these pests, to bring about a great reform. Just as in the case of some one who confines his attention closely to his line of business, another in a different line will see opportunities of extension and profit which his closeness of application precludes. Thus there has grown up a profession of men who go from one business house to another more thoroughly practicalizing businesses of which they before knew little or nothing.

In this case, exceptionally, the suggestion of relief came from Dr. L. O. Howard, who combined both the student and the practical mind, and by his experiments and announcements brought hope that practical extermination on a wide scale was possible. And when Dr. Howard saw that there was

even a broader and more radical relief possible than the use of oil (which idea he discovered to be of great practical though limited results) he was the first to encourage the broader idea of drainage when he observed this plan urged in the scientific press, as it was nearly seven years ago, and it was he who gave the necessary inspiration and encouragement to practical men who were interested. The death knell of the mosquito then began to sound when Dr. Howard inspired the carrying into effect of known resources of destruction. To use a bull, some concluded that the best of extermination methods was to destroy the mosquito before he was born and he endorsed the idea.

The world has moved toward practicalizing scientific knowledge rapidly in the last few years and this matter thus early fell into line. The mind of the entomologist who forcefully recommended the larger use of oil as a remedy was simply going a step beyond his real field and applying his knowledge to practical uses—which should be the object of all scientific study and not the thing *per se*. And then this line of thought inspired the idea that if oil was good in a limited way why not go further, and to the root of the matter, and destroy the breeding places. The seed-thought, however, had been dropped some time before when a casual remark had been made that a certain place, before experienced by this speaker as unendurable, had been cleared of mosquitoes by a piece of commercial drainage, but it was the work of the entomologist, as before stated, to nurture the idea to fruitage.

So when plain, practical men, who knew little of entomology, saw that water was needed to develop the pest, they were just so practical, or unpractical, if you please—such visionaries—as to say, let us do away with all water in inhabited sections where the pests breed. They simply put two and two together while heretofore these factors had been widely separated. And so widely and so long were they apart, that when the union was proposed the world laughed aloud, and a few of a certain caliber of mind are laughing yet.

There has been many a great idea retarded for ages because of this spirit of ridicule, and many a man has gone down under such opposition who had a thought which, if encouraged, would have blessed mankind ages before its final acceptance. We can all think of instances of this. Insistency often has been lacking.

But, fortunately, the mosquito cranks were as persistent as the pests themselves. They kept at the subject until they reversed the universal practise and they themselves began to draw blood. And so, probably, no crusade, which at first seemed so chimerical, ever made such strides as has the mosquito crusade, in the last three years or so, until now, that which less than a score of years ago began as an oiling experiment in a summer resort in the Catskills has spread to a crusade of drainage, filling and the like; and oil, which is indispensable in certain limited conditions, is now largely supplemented by extensive engineering operations. Now, engineers of national reputation are applying to their work the solid foundation laid by scientists and urging broad remedies upon communities and cities which have been sadly injured by the mosquito nuisance.

In a report (1903) on the improvement of a river in New England, an engineer, whose abilities have brought him into large projects in many sections of the country, makes the mosquito, and hence the malaria question, one of the moving causes for a proposed improvement. He calls to his aid a Harvard pathologist of world-wide

reputation who devotes many pages of this report to the mosquito question.

And in 1904, the same engineer reports on the improvement of another river, and gives prime attention to the results of investigations by the scientific experts from the Massachusetts Institute of Technology. Based on their reports, he is led to state:

> The results of this inquiry were startling. Every physician who was consulted testified that malarial disease was already prevalent and that it was apparently increasing and slowly extending.

He says:

> I was thus obliged at the outset to face a great sanitary problem which for the time overshadowed the other studies, for questions of public health are paramount and should have precedence over landscape design and facilities for brick-making or maket gardening.

We may interject just here, that when health and all improvements go together, as can be planned, then is the greatest good accomplished. The experts speak of 700 acres of a fresh pond marsh section (300 of which are constantly wet and soggy) where 'physicians report that every person in every house has had the fever,' and many of them state that this is 'the most dangerous section in twenty-five miles.' While the poor who live in this swampy territory were mostly affected, the report shows the disease spreading into the best districts where it is hilly.

These lines of investigation and the results are in exact conformity to the work done and reported upon by the North Shore Improvement Association of Long Island, some years previously. And it is most encouraging that engineering works are now being undertaken with such a strong appreciation of the importance of the mosquito question.

Landscape architects are seeking informing literature and are studying the subject and discovering that their profession also can materially aid the crusade and are recommending plans with a view to this question.

These two professions have been sadly blind to their opportunities for good. Not only has their work been simply negative—that was bad enough with their opportunities—but they have actually aided breeding in most cases. Within a few days the speaker has interested an owner in a badly infested home-site who has been spending thousands of dollars in following the plans of eminent landscape architects as to the lay-out of the wide lawns in front of his dwelling, while just in the woods behind there has existed for ages and still exists a breeding place extensive enough to ruin the pleasure which his home should yield him; and a surplus of pests to curse his neighbors. Now, this man is moving vigorously to get rid of this pest place, not that it has not been known heretofore that mosquitoes would breed in such places, but solely because it has been demonstrated that such work is entirely practical and certainly is highly desirable for comfort, for health, for increase in the value of his property and in the vast improvement to scenic effects. This is simply a case of neglecting a grand opportunity, but when these professions actually produce breeding grounds, their acts become a positive wrong to the public.

A gentleman of large means, recently met, has been encouraged to work on these lines on his vast property and now assures the speaker that he considers the question one of the most far-reaching before the people. This we have been endeavoring to show for nearly a decade. He feels that no money he is spending on roads and other improvements will pay him better. He also assures us that in the immediate vicinity where he has done work, which this crusade encouraged, he plainly notices a great difference in the number of pests

and he is going to continue the work with vigor for its absolutely paying results.

A little town in New England of less than a thousand inhabitants, whose chief industry is fishing, has recently become impressed with hope, founded on experiences elsewhere, that something might be done so that its thousands of acres of breeding grounds might be redeemed to agriculture, its desirable building sites relieved from the curse of mosquitoes which has always existed, and thus its lands become habitable, its taxable valuations increased, and so the town be greatly benefited. Inspired to join the crusaders, it had been working in a limited way and found excellent results, but it is now in a movement for raising and expending a large sum of public money to carry out very radical plans recommended to make these benefits assured and is asking the necessary legislative authority.

We know the case of the gentleman who bought a beautiful and extensive estate with the ban on it, that no one could live on it in July and August, but who was impressed with the anti-mosquito theory, by that same entomologist with the practical turn of mind, and went to work in good earnest and has made his large tract one without mosquitoes. His success led him naturally to wish others to be blessed likewise and he was instrumental in a campaign of greater proportions. One in this wider territory wrote the speaker within a few weeks that the success of the work was still continuing, although four summers had passed; and a person in another state has stated within a few days that he was visiting in the district in question this season and went through parts which he knew once to be infested beyond human endurance and he did not raise a mosquito. So much for the lasting effects of work thoroughly and practically executed.

But I am sure I do not need to rehearse smaller instances when all know of the transcendent achievements of Dr. Gorgas, both in Havana and in the Panama zone almost entirely as the result of practical mosquito extermination. Nor do you need to be reminded that the practical work of this kind in New Orleans, first under Dr. Kohnke and others and taken up later by the general government with all its prestige and power, through its Public Health and Marine Hospital Service under Surgeon General Wyman, with his able corps of specialists all working against the mosquito —that *this* brought about the end of the scourge of yellow fever here this season without the aid of frost and has added to the demand that this scourge and its attendant ruinous results to commerce through quarantine, be treated solely as a mosquito proposition and not as an inscrutable order of Providence. The speaker well recalls the force with which Dr. Kohnke at the second convention of the American Mosquito Extermination Society urged the necessity of screening the cisterns of New Orleans and spoke of his efforts to legally compass this. But his warning was acted on too late. He was then ahead of his time, but we are glad to say he is not now.

The demand is simply: Stop breeding mosquitoes and stop it by practical measures—no chimerical plans—nothing but what a child may comprehend. But do it thoroughly—do it so that results will last. Abolish forever the breeding places and be careful not to make new ones. Communities should put up money as they would to build a fine road—as is often the case, $10,000 a mile through a mosquito-infested section—and do it *before* building the road, and then the road, when built, can answer its full purpose of comfortable travel and traffic.

How much is the quinine bill of the country? And who can estimate, besides,

the sum of the misery and loss from malaria? Who will compute how far the loss in a yellow-fever epidemic would go to make everything safe along practical, common-sense lines? Is it not a fact that the expense of tardy work and the indirect and direct commercial losses resulting from this season's experience would easily have paid for New Orleans's exemption? How long are we to suffer these evils and pay the enormous and wretched penalty before people will rise and demand that this great crusade shall have complete course? This age is not the time to say that the work is too great. Put one year's loss and the cost of remedies, the country over, into the crusade, and it will be a paying investment financially, not to include other considerations. But again, do it thoroughly, so that you will not have to come back again in another year, or in ten years, for more money. Otherwise you have set back the cause for years. Note the radical work which the general government is doing in Panama and which it considers as necessary in every way before work is fully put under way. We said a year ago that the government could well spend a million dollars to make the zone safe. That has been spent already and results will justify the outlay and many times as much more. Chairman Shonts, of the Isthmian Commission, in an address last month, expressed the well-grounded hope that yellow fever, that supreme terror of the tropics, was extirpated—never to return again to Panama. Can one conceive all that such a statement means in relation to the cost and humanity of this great work?

Assistant Surgeon General Gorgas, in his report dated November 9, 1905, just to hand, reports that of the 22,000 employees during October, of which 4,000 were non-immunes, there was but one case of yellow fever and no deaths. He pertinently contrasts conditions for the same month in the zone now and under the French régime before the mosquito theory was known. Then there were reported 21 deaths and 84 cases, and many of each were not reported. Now he has care of one third more non-immunes and there is only one case. He maintains 'the results are solely and entirely due to the sanitary measures put in force.' He has an anopheles brigade reporting thousands of feet of ditches dug and cleared and other remedial work; and a stegomyia brigade reporting and remedying tanks, cisterns, barrels and other breeding places. To overcome the dangers from these pests which get to wing, he has a fumigating brigade, reporting houses fumigated containing 12,000,000 cubic feet, using 18,000 pounds of pyrethrum and 7,800 pounds of sulphur. Dr. Gorgas finds a steady decrease in cases of yellow fever under this work, while there is a steady increase in the number of persons susceptible. He considers the sanitary question in Panama settled—that the largest necessary force of laborers can work there without suffering from yellow fever and that 'the general health can be kept as good as if they were digging a canal in the healthy part of Maryland.' Now all this you may hear stated by others, but bear in mind it is the practical side of mosquito extermination we are trying to emphasize, and this is all practical and highly profitable in every way and bears well to be repeated. Also recognize that to some extent such work is necessary in many communities in the states and that it is just as profitable here in a humanitarian view as a financial proposition and in other aspects.

No progressive man will object that the general government is spending hundreds of millions on good roads, on irrigation, on river and harbor improvement; that the Empire State votes 150 millions for good roads and canals; but when it is considered that in some of these cases the benefit will

come only to sparsely settled sections and result in aiding comparatively limited areas and valuations, the thought arises, why should not some of these vast sums be used in blessing the country by driving out the mosquito and malaria and yellow fever, bettering the condition of the less favored people—for they suffer most—changing marsh and swamp areas into places of fertility, beauty and oftentimes into places of pleasant habitation? When it is considered that such work is largely needed in close centers of population where thousands will be benefited instead of scores, and where resultant increase of tax valuations will shortly entirely repay cost, the urgency of the subject as a public work is manifest. This body and all others working for the general good should state and reiterate this position until we get public action.

It has taken some years to get strength enough in the idea to obtain appropriations, but these are now coming in many places. Numbers of cities and communities are awakening and acting. The Department of Health of the city of New York has been expending this season in one borough —Richmond—an appropriation of $17,000 under Dr. A. H. Doty, the health officer of the port, and it is to be hoped the results will encourage work in other boroughs. But all public work particularly, we repeat, should be done most thoroughly or the press and people will raise such opposition as to cause a set-back in the practical work of a thoroughly scientific problem.

The city of New York is also helpfully acting in the reform by utilizing part of its inorganic waste in filling in breeding places instead of carrying it out to sea and dumping it so that much floats back on to adjacent shores. In the southern part of the borough of Brooklyn, Coney Island Creek is being filled in, which, guardedly done, will prevent its waters from saturating hundreds of acres of marsh land where mosquitoes are now famous. This evil and this benefit were pointed out some seasons ago when a crusade was initiated there by the late Mr. Wm. C. Whitney.

Some two or three years ago we were greatly encouraged in learning that the Italian government had made a contract with some German capitalists to drain the great marshes about Rome—to destroy the breeding places of mosquitoes and thus render the section healthy and inhabitable. But it seems that this great improvement and blessing to a race has been kept back until now by the obstruction of a few sporting noblemen (in title) who wished to have the marshes left for their personal pleasure. Now the press informs us the work is to go forward and the promoters are to be paid in hitherto worthless land. What a suggestion for our country along lines of marsh improvement and the obstruction met from personal interests of a few seek pleasure or profit.

The great benefits of mosquito extermination we feel, are to be accomplished by a careful education of the public mind and a judicious effort for laws and public appropriations, by cooperation of general and state governments, of cities and rural sections, of individuals and public men in a short, strenuous campaign. What need of taking decades in these moving times? And it is on these lines that the American Mosquito Extermination Society is earnestly working, and I bespeak for it your influence and cooperation.

It would take too much of your time to speak of this phase—the basal work, education—education of the public school children of the country, the lawmakers, the editors and press writers, the civic organizations, the professions interested, the great mass of the people. But this work our society is striving to do and has its members distributed well over America, to whom our literature is scattered, and we

frequently hear of its bearing good fruit in campaigns. In our society, either as officers or on the advisory boards, are many men of broad influence in the country. Among these the earliest to go into the movement, inspired by the entomologist before referred to, were Matheson, Kerr, Miller, Hoyt, Cravath, Rand and Wetmore —business men of largest affairs.

We have got such men together, with many others known over the world, into a society, which, according to its constitution, seeks 'to unite in a general body, persons believing in the various great evils resulting from the unrestrained breeding of mosquitoes in civilized sections, and in the practicability of their extermination therefrom, by private and public systematic operations.'

For these worthy objects we ask your active cooperation with us and in closing thank you for your attention.

(To be continued.)

SCIENTIFIC BOOKS.

The Analytical Theory of Light. By JAMES WALKER. New York, The Macmillan Company. Pp. xv + 412. $5 net.

The Electromagnetic Theory of Light. By CHARLES EMERSON CURRY. New York, The Macmillan Company. Part I. Pp. xv + 400.

Walker's 'Analytical Theory of Light' is, perhaps, the most complete treatment of the subject so far attempted from the standpoint of the general wave theory, without any special assumption as to the character of the waves or the nature of the transmitting medium. With this restriction in mind, it is not surprising to find relatively much more space given to the older and more worked-over parts of the subject, such as interference, diffraction, isotropic and crystalline reflection and refraction and the interference of polarized light, as contrasted with absorption, dispersion and magneto-optics, those portions which at present seem more fruitful of interesting and important results. While the book is built on a rigorous analytical framework, nevertheless frequent comparison with experimental facts, and more sparing application of theory to instrumental methods keep the reader in touch with the physical side of the subject—to which end numerous references to the literature of the various special fields also assist. The book is written in a clear and attractive style, and its value as a reference work is increased by an index as well as by appendices dealing with the properties of Bessel's, Struve's and Lommel's functions.

It is in one sense hardly fair to criticize a book because it is too exactly what its author intended it to be; at least one should, while questioning his judgment, commend his pertinacity of purpose. This applies to the second of the above books, Part I. of Curry's 'Electromagnetic Theory of Light,' in which, as is stated in the preface, 'empirical facts' are referred to 'only where a comparison with theoretical results seemed of interest.' One must regret that so few cases 'seemed of interest'—for the result is a book unnecessarily abstract, which, while entirely modern in treatment, and sufficiently cognizant of recent theoretical discussions, is out of touch with the experimental side of the science. While this general method of treatment has been most successfully applied to the more finished science of mechanics, it hardly seems at present the best for the less developed field of optics. This point of view is, perhaps, responsible for one or two rather amusing misstatements, as for instance (p. 13) that the varying sensibility of the eye to different wave-lengths, follows because the usual expression for the intensity of a ray of light

$$\left(I = \frac{m\pi^2\nu^2a^2}{\lambda^2}\right)$$

contains the wave-length.

The treatment is throughout based on the electro-magnetic theory of Maxwell, but a very considerable amount of space is given to the discussion of 'primary' and 'secondary' waves, the exact definition of which and their special treatment is due to the author. Aside from this the ground covered is about the same as in the earlier chapters of Walker's treatise, with, however, emphasis laid on dif-